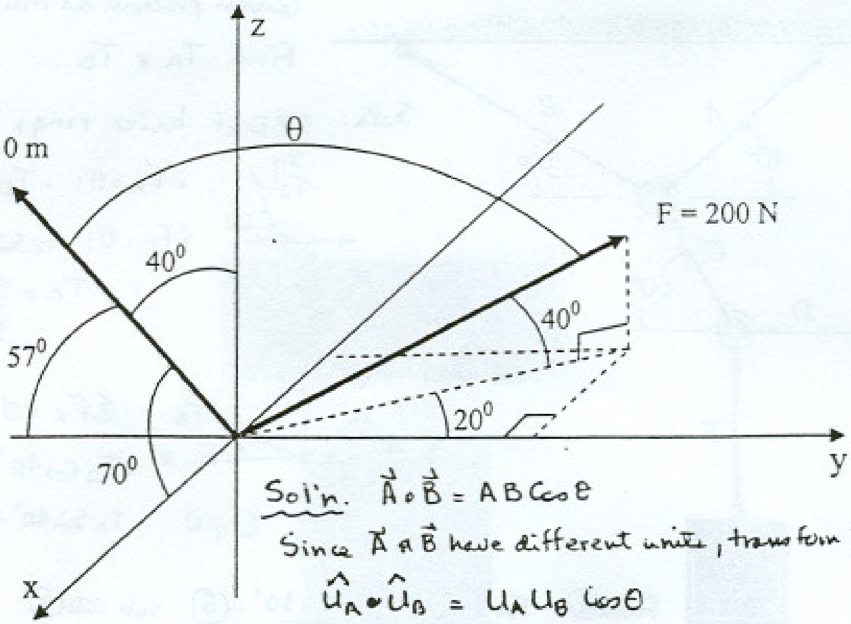
1) Determine the angle, θ, between the vector $\vec{r}$ and the vector $\vec{F}$.



Sol'n. $\vec{A} \bullet \vec{B} = AB \cos\theta$

Since $\vec{A}$ & $\vec{B}$ have different units, transform to

$\hat{u}_A \bullet \hat{u}_B = u_A u_B \cos\theta$

or $\theta = \cos^{-1}(\hat{u}_r \bullet \hat{u}_F)$

Given Above Problem, Find θ.

$\hat{u}_F = -\cos 40^\circ \sin 20^\circ \hat{i} + \cos 40^\circ \cos 20^\circ \hat{j} + \sin 40^\circ \hat{k}$

$\hat{u}_F = -0.2620\hat{i} + 0.7198\hat{j} + 0.6428\hat{k}$

$\hat{u}_r = \cos 70^\circ \hat{i} + \cos(180^\circ - 57)\hat{j} + \cos 40^\circ \hat{k}$

$\hat{u}_r = 0.3420\hat{i} + (-0.5446)\hat{j} + 0.7660\hat{k}$

$\theta = \cos^{-1}(0.342\hat{i} - 0.5446\hat{j} + 0.7660\hat{k}) \bullet (-0.2620\hat{i} + 0.7198\hat{j} + 0.6428\hat{k})$

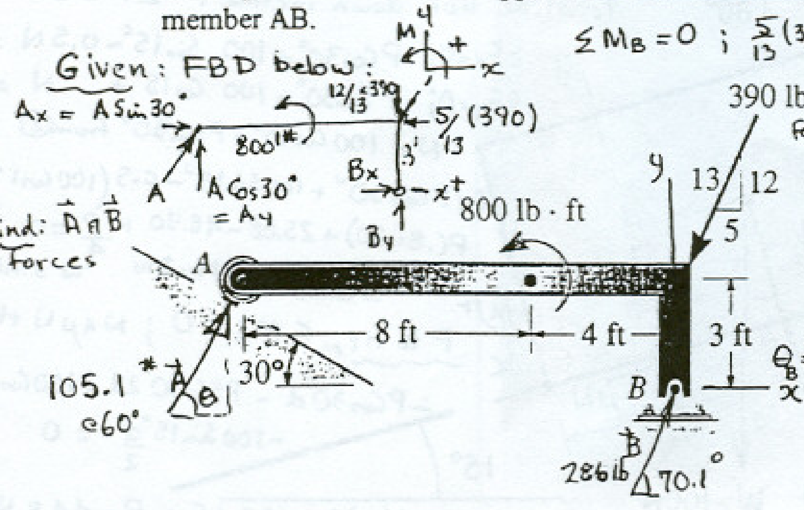
$\theta = \cos^{-1}(-0.0896) + (-0.3920) + (0.4924)$

$\theta = \cos^{-1}(0.0108)$; $\theta = 89.4^\circ$

4) Calculate the reaction forces that must be present at A and B if the body shown below is in equilibrium under the applied forces and moments. Neglect the thickness of the member AB.

Given: FBD below:

Find: $\vec{A}$ & $\vec{B}$ Forces



$\Sigma M_B = 0$; $\frac{5}{13}(390^{\#})(3ft) - A\sin 30^\circ(3ft) - A\cos 30^\circ(12ft) + 800^{'\#} = 0$

$450^{\#'} + 800^{\#'} = A(1.50 + 10.392)$

For $A, \theta_A = 60^\circ$, $A = 105.1$ lb, $A_x = 52.6^{\#}$, $A_y = 91.0^{\#}$

$\Sigma F_x = 0$; $52.6 - \frac{5}{13}(390) + B_x = 0$

$B_x = 150 - 52.6 = 97.4^{\#} \rightarrow$

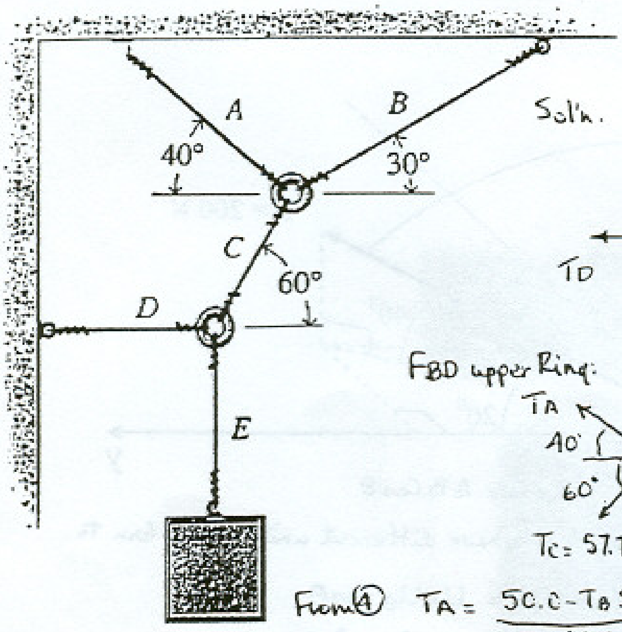
$\Sigma F_y = 0$; $91.0^{\#} - \frac{12}{13}(390) + B_y = 0$

$B_y = 360 - 91.0 = 269^{\#} \uparrow$

$\theta_B = \tan^{-1}\frac{269}{97.4}$

$B = \sqrt{97.4^2 + 269^2} = 286$ lb @ 70.1° θ_B

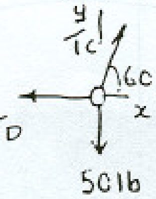
2) Calculate the tension in Cables A and B given that the block hanging from Cable E weighs 50 lb.



Given problem as illustrated

Find T_A & T_B.

Sol'n. FBD of lower ring, $\Sigma F = 0$.

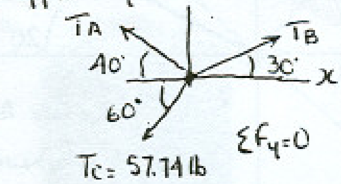


$\Sigma F_x = 0: \; -T_D + T_C \cos 60^\circ = 0$ ①

$\Sigma F_y = 0: \; T_C \sin 60^\circ - 50\text{lb} = 0$

$T_C = \dfrac{50.0\text{lb}}{\sin 60^\circ} = 57.74\text{lb}$ ②

FBD upper Ring:



$\Sigma F_x = 0$ ③

$-T_A \cos 40^\circ - 57.74\text{ lb} \cos 60^\circ + T_B \cos 30^\circ = 0$

$\Sigma F_y = 0 \quad T_A \sin 40^\circ - \underbrace{57.74\text{ lb} \sin 60^\circ}_{50.0\text{lb}} + T_B \sin 30^\circ = 0$ ④

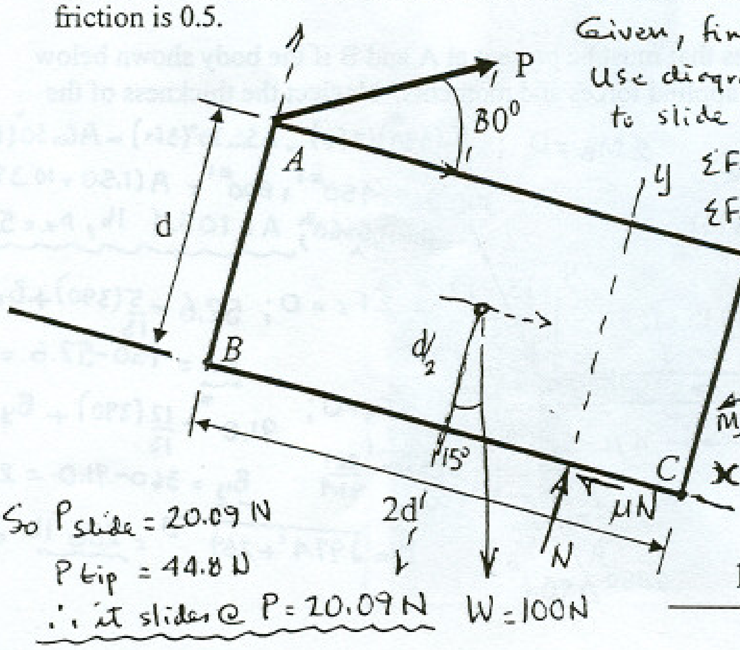
From ④ $T_A = \dfrac{50.0 - T_B \sin 30^\circ}{\sin 40^\circ}$ ⑤ sub into ③

$-\left[\dfrac{50.0 - T_B \sin 30^\circ}{\sin 40^\circ}\right] \cos 40^\circ - 28.87 + T_B \cos 30^\circ = 0 \; ; \; T_B \cos 30^\circ - \left[\dfrac{50.0 \cos 40^\circ}{\sin 40^\circ}\right] + T_B \left[\dfrac{\sin 30^\circ \cos 40^\circ}{\sin 40^\circ}\right] - 28.87 = 0$

$T_B = \dfrac{50.0 \dfrac{\cos 40^\circ}{\sin 40^\circ} + 28.87}{\dfrac{\sin 30^\circ}{\tan 40^\circ} + \cos 30^\circ} = \dfrac{88.45}{1.4619} = 60.50\text{lb.}$ So $T_B = 60.5$ lb

From ⑤ $T_A = \dfrac{50.0 - (60.51) \sin 30^\circ}{\sin 40^\circ} = 30.72$ lb, So $T_A = 30.7$ lb

8) Calculate the force P required to cause the body shown below to begin to move. The body has a weight of 100 N applied to the center of the box. The coefficient of static friction is 0.5.



Given, find P to just move box. $\mu_s N = 0.5 N$

Use diagram as FBD, check force P to slide box down incline: $\Sigma F = 0$.

$\Sigma F_x = 0; \; P \cos 30^\circ + 100 \sin 15^\circ - 0.5 N = 0$ ①

$\Sigma F_y = 0; \; P \sin 30^\circ - 100 \cos 15^\circ + N = 0$ ②

$N = 100 \cos 15^\circ - P \sin 30^\circ$ from ②

$0 = P \cos 30^\circ + 100 \sin 15^\circ - 0.5 (100 \cos 15^\circ - P \sin 30^\circ)$

$P(.8660) + 25.88 - 48.30 + \dfrac{P}{4} = 0$

$P = 20.09$ Newtons to slide

P to tip, $\Sigma M_C = 0$; N & μN thru C.

$-P \cos 30^\circ d - P \sin 30^\circ 2d + 100 \cos 15^\circ (d) - 100 \sin 15^\circ \dfrac{d}{2} = 0$

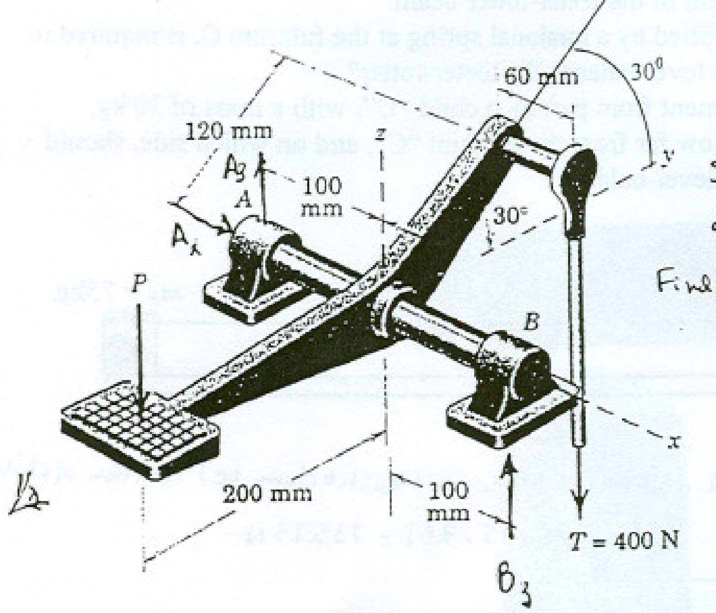
$P(1.866)d = 83.65$; $P = 44.8$ Newtons

So $P_{slide} = 20.09$ N

$P_{tip} = 44.8$ N

∴ it slides @ $P = 20.09$N

5) A vertical force P on the foot pedal of the bell crank is required to produce a tension T of 400 N in the vertical control rod. Determine the corresponding bearing reactions at A and B. The bearings are properly aligned and only bearing A is a thrust bearing. Bearings A and B are both 100 mm away from the y axis.



Given problem as shown

Find A_x, A_y, A_z, B_x, B_y, B_z

Using figure as FBD

Since there are no forces in the x & y directions $A_x = 0, A_y = 0, B_x = 0, B_y = 0$

Find P from ΣM_x axis $= 0$

$P(200\text{mm}) - 400(120\text{mm}\cos 30°) = 0$

$P = 207.85$ N in dir shown.

$P = 208$ N

$\Sigma M_{A(y\,axis)} = 0$

$B_z(200) - 400N(160) - 207.85(100) = 0$

$B_z = 424$ N in direction shown

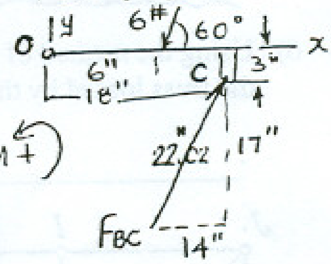
$\Sigma M_{B(-y\,axis)} = 0$

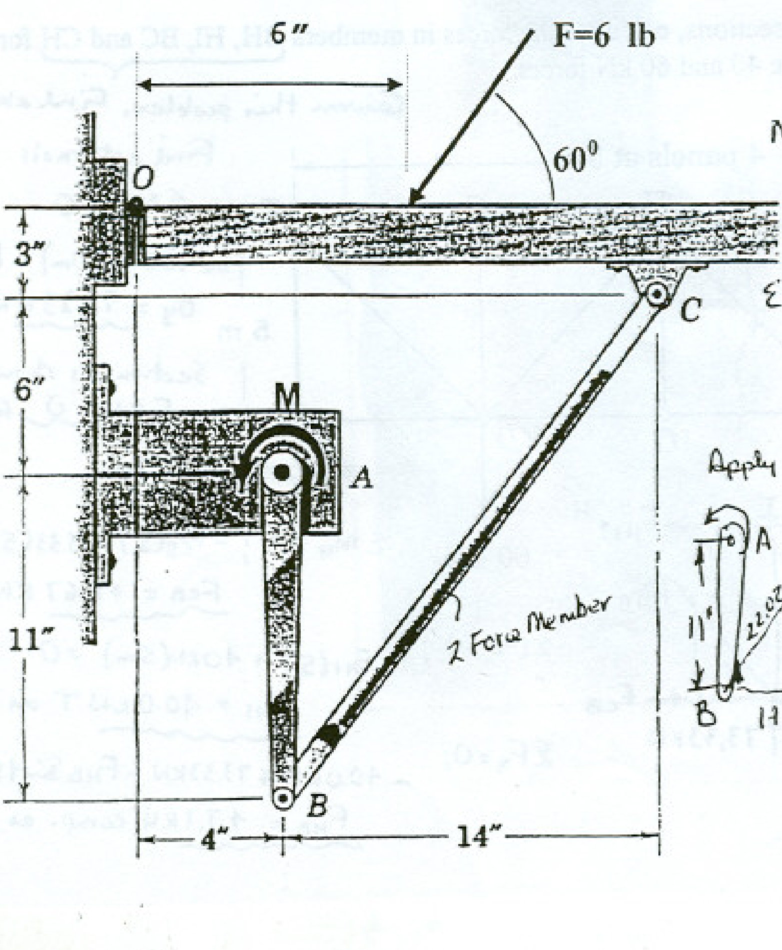
$-A_z(200) + 400(40) + 207.85(100) = 0$

$A_z = 183.9$ N in dir. shown

7) The door shown below is opened by swinging the door about the hinge at O. If the rotation of the door is being resisted by a 6 lb force applied as shown, calculate the moment M, applied to member AB at A, required to begin opening the door. Neglect the weight of the door and all members.

Given, find M_A: FBD of door OC





$\Sigma M_O = 0;\ -6^{\#}\sin 60°(6") + F_{BC}\frac{11}{22.02}(18") + F_{BC}\frac{14}{22.02}(3")$

$F_{BC}(15.818) = 31.177;\ F_{BC} = 1.973$ lb

Apply F_{CB} to arm AB; $\Sigma M_A = 0$

$-(11)\,1.973\text{lb}\left(\frac{14}{22.02}\right) + M_A = 0$

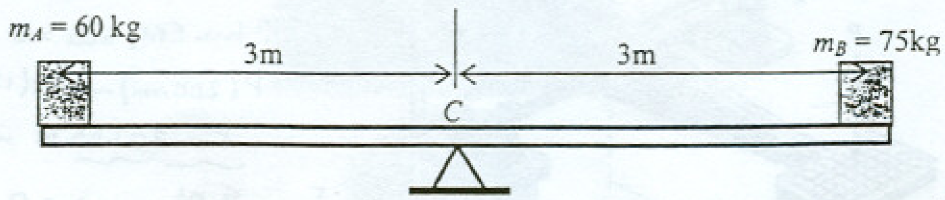
$M_A = 13.80$ ft.lb.

3) Two students, A and B, decide to ride on a 6 m long teeter-totter as shown below. Student A has a mass of 60 kg while student B has a 75 kg mass. The teeter-totter beam has a frictionless bearing at its center, C; with each student positioned 3m from the fulcrum at C.

a) Draw a Free Body Diagram of the teeter-totter beam.

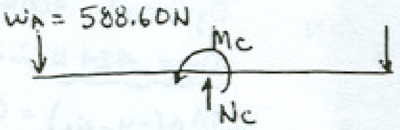
b) What couple moment, applied by a torsional spring at the fulcrum C, is required to maintain equilibrium and level-balance the teeter-totter?

c) Instead of the couple moment from part b), a child "D", with a mass of 30 kg, comes along for a ride. How far from the fulcrum "C", and on which side, should child "D" sit to maintain level-balance?



Given: As indicated. Find (a) FBD (b) Mc for Equilibrium (c) Position of Child D.

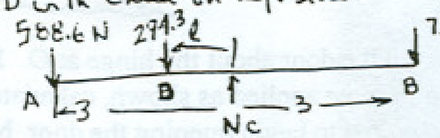
(a)



(b) $\Sigma M_C = 0 \quad W_A(3.0m) + M_C - W_B(3.0m) = 0;\quad M_C = -588.6(3) + (735.75)(3)$

$M_C = 441\ Nm$

(c) FBD with Child on Left Side.



$W_D = 30 \times 9.81 = 294.3\ N$

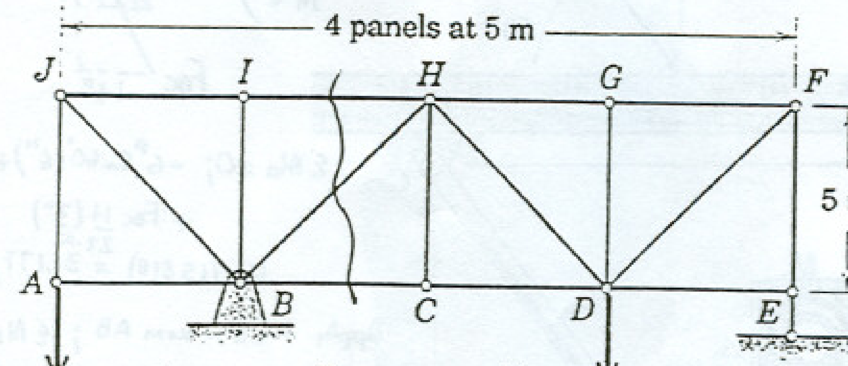
$\Sigma M_C = 0;\ 588.6(3) + (294.3)\ell - 735.75(3) = 0$

$\ell = \dfrac{735.75(3) - 588.6(3)}{294.3} = 1.500\ m.$

Child should sit 1.5m left of C for equilibrium.

6) Using the method of sections, calculate the forces in members BH, HI, BC and CH for the truss loaded by the 40 and 60 kN forces.

Given this problem, Find above forces.



Find externals

$\Sigma M_E = 0$

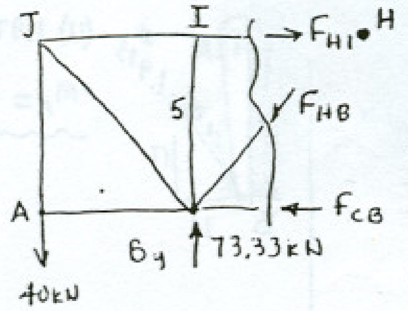
$0 = 40kN(20m) - B_y(15) + 60kN(5)$

$B_y = 73.33\ kN$ up. $B_x = 0$

Section as shown, noting $F_{CH} = 0$, force member

$\circlearrowleft M.$

FBD Section



$\Sigma M_H = 0;\ -F_{CB}(5) - 73.33(5) + 40(10) = 0$

$F_{CB} = +6.67\ KN$ comp. as shown

$\Sigma M_B = 0;\quad -F_{HI}(5) + 40kN(5m) = 0$

$F_{HI} = 40.0\ kN\ T$ as shown.

$\Sigma F_y = 0;\quad -40.0kN + 73.33kN - F_{HB}\sin 45^\circ = 0$

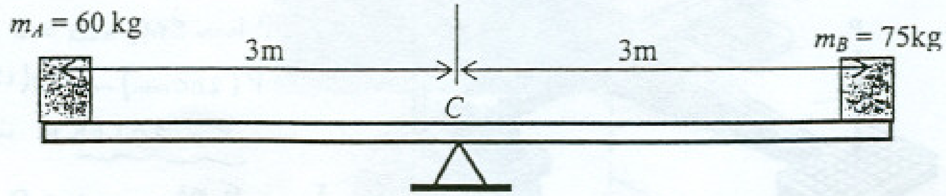
$F_{HB} = 47.1kN$ comp. as shown.

3) Two students, A and B, decide to ride on a 6 m long teeter-totter as shown below. Student A has a mass of 60 kg while student B has a 75 kg mass. The teeter-totter beam has a frictionless bearing at its center, C; with each student positioned 3m from the fulcrum at C.

a) Draw a Free Body Diagram of the teeter-totter beam.

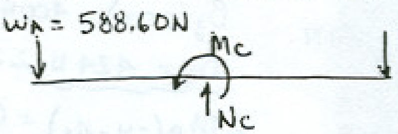
b) What couple moment, applied by a torsional spring at the fulcrum C, is required to maintain equilibrium and level-balance the teeter-totter?

c) Instead of the couple moment from part b), a child "D", with a mass of 30 kg, comes along for a ride. How far from the fulcrum "C", and on which side, should child "D" sit to maintain level-balance?



Given: As indicated. Find (a) FBD (b) Mc for Equilibrium (c) Position of child D.

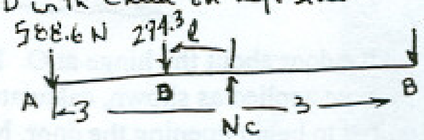
(a)



(b) $\Sigma M_C = 0 \quad W_A(3.0m) + M_C - W_B(3.0m) = 0;\quad M_C = -588.6(3) + (735.75)(3)$

$M_C = 441\ Nm$ ↻

(c) FBD with Child on Left Side.



$W_D = 30 \times 9.81 = 294.3\ N$

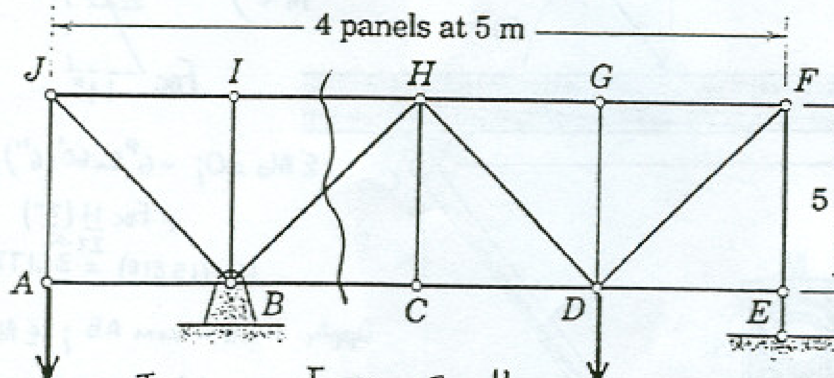
$\Sigma M_C = 0;\ 588.6(3) + (294.3)\ell - 735.75(3) = 0$

$\ell = \dfrac{735.75(3) - 588.6(3)}{294.3} = 1.500\ m.$

Child should sit 1.5m left of C for equilibrium.

6) Using the method of sections, calculate the forces in members $\underbrace{\text{BH, HI, BC and CH}}$ for the truss loaded by the 40 and 60 kN forces.

Given this problem, Find above forces.



Find externals

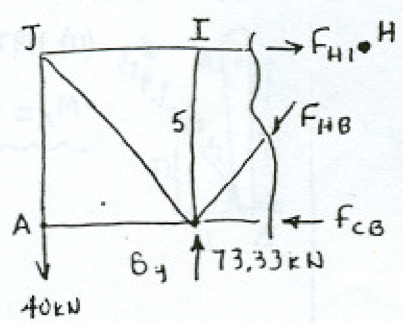
$\Sigma M_E = 0$

$0 = 40kN(20m) - B_y(15) + 60kN(5)$

$B_y = 73.33\ kN$ up. $B_x = 0$

Section as shown, noting $F_{CH} = 0$ force member

+↺M.



FBD Section

$\Sigma M_H = 0;\ -F_{CB}(5) - 73.33(5) + 40(10) = 0$

$F_{CB} = +6.67\ KN$ comp. as shown

$\Sigma M_B = 0;\ -F_{HI}(5) + 40kN(5m) = 0$

$F_{HI} = 40.0\ kN\ T$ as shown.

$\Sigma F_y = 0;\quad -40.0kN + 73.33kN - F_{HB}\sin 45° = 0$

$F_{HB} = 47.1kN$ comp. as shown.